Optimization of stimulus characteristics for vestibular stochastic resonance to improve balance function

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Stochastic resonance (SR) is a mechanism by which noise can assist and enhance the response of neural systems to relevant sensory signals. Recent studies have shown that applying imperceptible stochastic noise electrical stimulation to the vestibular system significantly improved balance and ocular motor responses. The goal of this study was to optimize the amplitude of the stochastic vestibular signals for balance performance during standing on an unstable surface.

Subjects performed a standardized balance task of standing on a block of 10-cm-thick medium-density foam with their eyes closed. Balance performance was measured using a force plate under the foam block and using inertial motion sensors placed on the torso and head segments. Stochastic electrical stimulation was applied to the vestibular system through electrodes placed over the mastoid process. Subjects were tested at seven amplitudes in the 0.01-30Hz frequency range. The root mean square of the signal increased by 30 microamperes for each ±100 microampere increment in the current range of 0 - ±700 microampere. Six balance parameters were calculated to characterize the performance of subjects during the baseline and the stimulus periods for all seven amplitudes. Optimal stimulus amplitude was determined as the one at which the ratio of parameters from the stimulus period to the baseline period for any amplitude range was less than that for the no stimulus condition on a minimum of four of six parameters. Results from this study showed that balance performance at the optimal stimulus amplitude showed significant improvement with the application of the vestibular SR stimulation. The amplitude of optimal stimulus for improving balance performance in normal subjects was in the range of ±100-±300 microamps.

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